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Active Cruise Control

Initial Print Date:01/03 Revision Date:03/03

Model: E65/E66

Production: Start of Production MY 2003

Objectives:

After completion of this module you should be able to:

- Properly operate the ACC system.
- Explain the operation of the ACC system.
- Perform the alignment procedure for the ACC Control Unit.

Purpose of the System

Active Cruise Control (ACC) is an extension of conventional cruise control. ACC is a comfort system which assists the driver when traveling on open highways. A radar sensor monitors the distance, angle and speed of moving objects in front of the vehicle and strives to maintain a fixed distance behind the object. Vehicle ranging and speed control are achieved by means of engine management (Cruise Function of DME) and brake intervention (DSC).

The driver can preselect a desired speed (in 5 mph increments) and choose between 4 following distances (expressed in time intervals).

Note: Vehicles with ACC do not have "Normal" Cruise control. If the ACC system fails or enters a fault mode the vehicle does not default to "Normal"Cruise.

Safety Note:

ACC is not an impact protection system and <u>CANNOT</u> warn against or prevent collisions.
The driver must continue to intervene in critical situations.

System Components

The ACC system consists of the following components:

- Sensor-Control Module Unit
- Steering Column Stalk Switch
- Instrument Cluster Display

Sensor-Control Module Unit

The Sensor-Control Module Unit is mounted to the front of the vehicle by means of an aluminum bracket with an intermediate plastic bracket.

The Control Unit is self contained and assumes control of following distance, speed and acceleration. The ACC control unit communicates with the appropriate modules via the PT-CAN.

The radar sensor, which is contained in the control unit, incorporates a transmitter and receiver. The transmitter frequency is 76-77 GHz and is active at speeds above 20 mph. The sensor shuts down when system voltage is < 10 V or > 17 V, and a fault is stored.

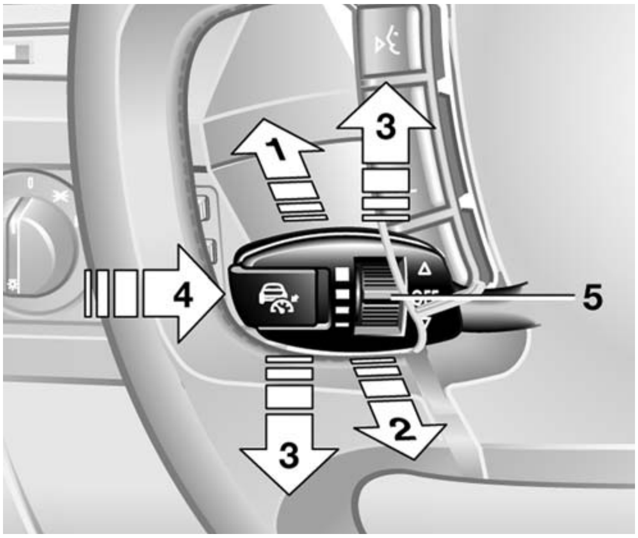
The ACC control unit is protected against shorts to B+ or B-, polarity reversal and open circuits.

Steering Column Stalk Switch

The Steering Column Stalk Switch for ACC control is located on the lower left of the steering column.

The stalk switch allows driver input and control over the following actions:

- Activate System, Store and Increase desired speed. (1)
- Activate System, Store and Decrease desired speed. (2)
- Interrupt System operation. (3)
- Press Button with System active to select stored speed. (4)
- Select Following distance time interval. (1.5,1.8, 2.2, 2.8 seconds) (5)



Instrument Cluster Display

The instrument cluster display is responsible for visual indication of ACC operation.

1. Indicator for stored Desired speed.
2. Indicator for detected vehicle.
3. Indicator to show selected follow distance.
4. Digital speed display.

Note:
1,2, and 3 are shown when the system is active.
4 is shown for a short time when the desired speed is input.

Vehicle in display is outlined:

System is active and no vehicle in front is detected.

Vehicle in display is solid:

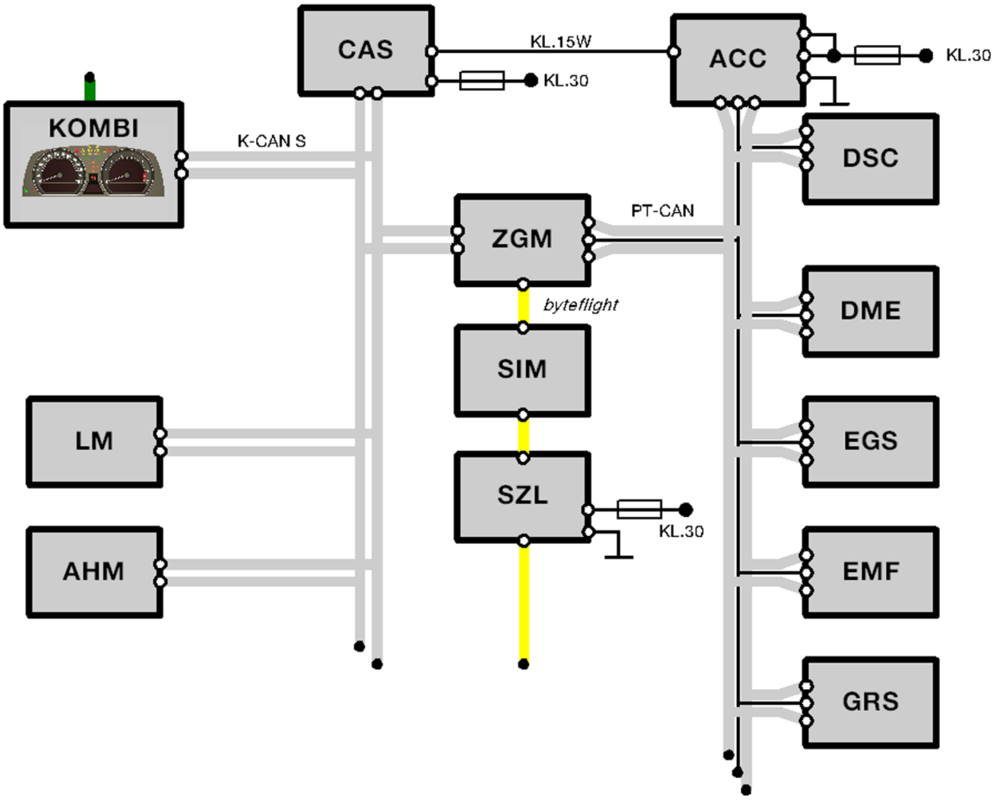
System is active vehicle in front is detected.

Take Over Request
Vehicle in display is in triangle and Flashes:
Driver should intervene by braking or taking evasive action as required. ACC cannot set following distance.

System Interfaces

The following systems interface with the ACC system:

- DME
- DSC
- Steering Angle Sensor
- EGS
- Parking Brake
- Yaw Rate Sensor



DME

The DME interface has the following functions:

- Controls engine torque based on requests from the ACC control unit.
- Controls engine speed based on requests from the ACC control unit.
- Monitors throttle and brake pedal applications for speed control.

DSC

Interface functions of the DSC include:

- DSC provides the ACC control unit with wheel speed information.
- Communication request for brake application are received by the DSC from the ACC.

For ACC to be active and operational, the brake system, parking brake and DSC must all be fault free. Pressing the brake pedal or parking brake (EMF) will always deactivate the system.

When possible, ACC will decelerate the vehicle by of means of torque or throttle intervention in the DME. If engine drag torque or engine speed reduction is not sufficient for deceleration the ACC control unit requests the DSC hydraulic unit to build up brake pressure for adjustment of the deceleration.

If deceleration is triggered by the ACC, the brake lights are activated by the DSC dependent on a specific pressure or deceleration rate.

With ACC active, DSC operates in a normal manner. ACC is deactivated in the event of stability safeguarding interventions by DSC.

The DSC control unit informs the EGS that brake intervention is taking place, so that the EGS control module can downshift the transmission to protect the brakes against over loading.

Steering Angle Sensor

ACC receives steering angle position information from the Steering Angle Sensor.

EGS

The EGS-ACC interface serves to implement comfort functions only, no safety related functions are affected.
The EGS includes special shifting maps to suit the various operating conditions of the ACC.
A kick down is triggered on downhill slopes with ACC brake intervention active, to prevent overheating of the brake system.

When the transmission selector is moved to N, P or R the ACC is deactivated and cannot be activated.

EMF

The ACC is deactivated should the parking brake (EMF) become active.

Yaw Rate Sensor

The Yaw Rate or rotation rate sensor supplies information concerning vehicle dynamics on to the ACC sensor. through the DSC control unit.

Principle of Operation

ACC is a ***Comfort Function*** and ***NOT*** a Safety function.

The driver alone is responsible for the use of the ACC system including:

- Speed Selection
- Following Distance
- Acceptable weather conditions including visibility and road conditions for cruise operation

The system can be overridden at any time by the driver. Accelerating does not deactivate the system. Braking results in system deactivation.

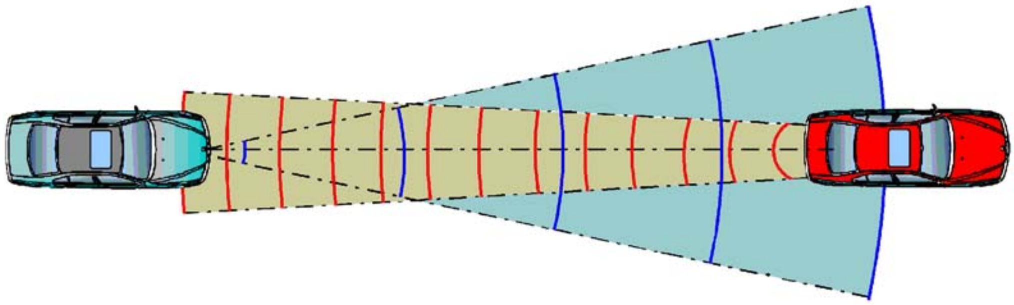
All stored information, speed, following distance, are reset with every key activation and in the case of non ACC requested DSC intervention.

The ACC system controls the following distance and cruise speed when the vehicle is traveling between 20 mph and 110 mph.

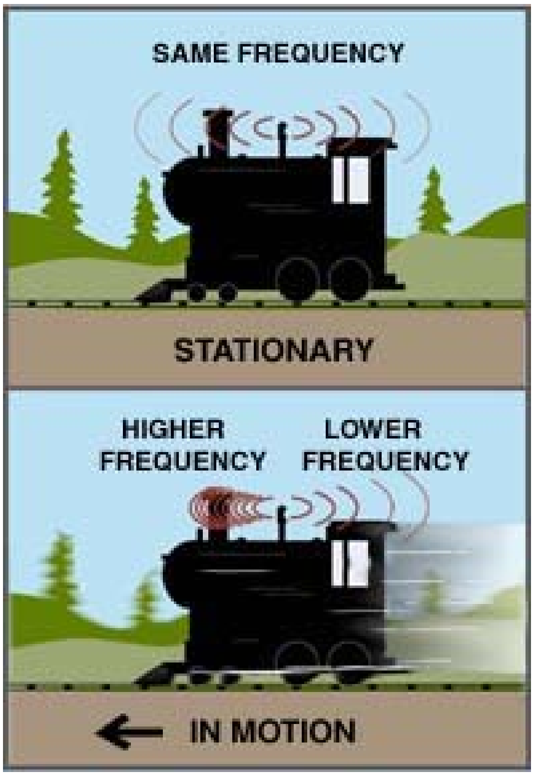
Radar Sensor

The Radar Sensor of the ACC system is integrated into the ACC control unit that is mounted in the front of the vehicle.

The ACC emits radar waves in order to detect objects, passenger vehicles, trucks, buses and motorcycles. The pulses, emitted every 100ms for 10ms travel at the speed of light. An echo is returned to the ACC control unit when a radar reflecting object is located in the range of the beam. Distance from the object is determined by signal propagation time. (The time difference between when the signal is sent out and received back.



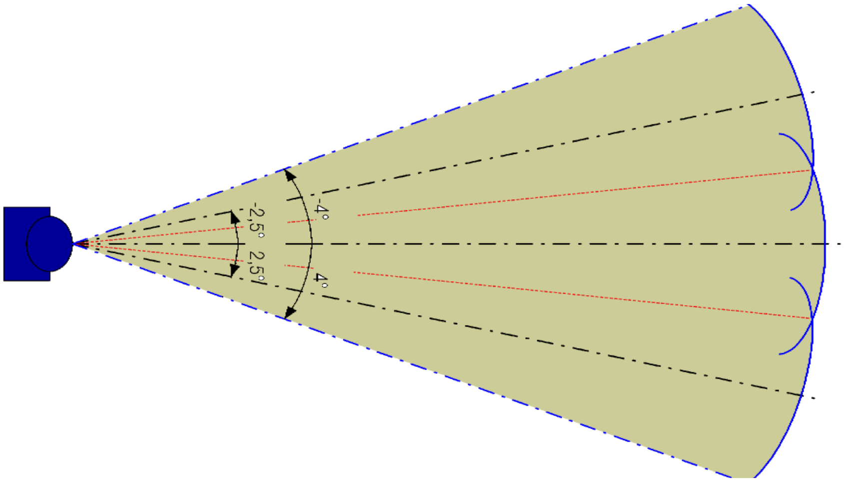
The relative speed difference between the vehicle and the object is determined by the Doppler effect of the Radar. The Doppler effect was named after Christian Doppler, who first came up with the idea in 1842. He thought that the frequency of sound (or in the case of radar, radar waves) waves would change if either the source or the observer was moving. If they were approaching, the frequency would be higher; if they were moving away, the frequency could be lower.



There are many everyday examples of the Doppler effect: train whistles, police and fire sirens, race car engines. In every case, there is an audible change in pitch as the source approaches and then passes an observer.

One way to visualize the Doppler effect is to think of sound waves as pulses emitted at regular intervals. Imagine walking forward. Each time you take a step, you emit a pulse. Each pulse in front of you would be a step closer together than if you were emitting them while standing still; each pulse behind you would be a set further apart. The pulses in front of you have a higher frequency than at rest and the pulses behind you have a lower frequency at rest.

In order to determine the angle of the object, the measuring range is sensed by three radar beams. The middle beam points straight ahead, the other two beams point 2.5⁰ to the sides. The total horizontal sensing range of the ACC is 8⁰ or +/- 4⁰ from vehicle centerline. The radar beam is capable of reading the entire width of a lane at 120m.



ACC Controller

The ACC controller receives distance, relative speed and angle information from each object that is detected. The ACC decides whether the DME needs to accelerate, maintain speed or decelerate the vehicle and if DSC intervention is required. These functions are broken into sub components in the ACC.

- Set Speed Controller
- Follow Controller
- Curve Speed Controller

Set Speed Controller
This controller passes vehicle speed information on the DME.

Follow Controller
This controller decides which object will become the target object. It attempts by way of interventions in the DME and DSC, to set a constant time gap to the leading vehicle.

Curve Speed Controller
This controller evaluates inputs so that speed is limited on curves so that the transversal acceleration does not become uncomfortable. It prevents rapids acceleration of the vehicle when the target object is lost in a curve. (Only if the vehicle's steering wheel is turned.)

Operation

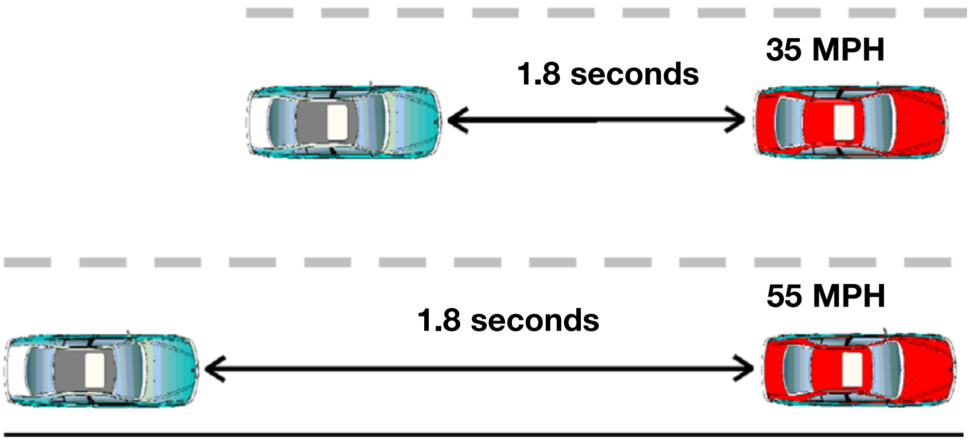
If there is no object in front of the vehicle, the ACC system operates as a normal cruise control. The desired speed input by the driver is regulated.

When an object is detected within the lane the ACC illuminates the object sensed indicator. If the object being followed is traveling at a slower speed than is set by the cruise control, the vehicle speed will be adapted (slowed) through either DME or DSC intervention to maintain the requested follow distance (timed in seconds).

The distance to the lead object will vary with the time interval chosen by the driver and vehicle speed. The speed of the vehicle will never exceed the preset cruise request of the driver.

When the object is no longer in front of the vehicle, the preset speed request will be resumed.

Note:
The ACC will only detect moving objects. Objects that are stationary (stopped) will be ignored.



Constant interval based on seconds, distance changes based on speed.

To maintain proper follow distance the ACC system must be able to perform the following tasks:

- Detect lead objects by radar sensing up to a distance of approx. 120m.
- Measure the distance, angle and relative speed of the lead object.
- Calculate in advance the presumed vehicle course.
- Select the relevant lead object for vehicle to object ranging.
- Adapt the actual vehicle speed to that of the lead object by:
  - Accelerating (Maximum acceleration rate 1.2 m/s^2.
  - Decelerating (Maximum deceleration rate 2.0 m/s^2.
- Monitor Lateral Acceleration (Maximum lateral acceleration 3.0 m/s^2.

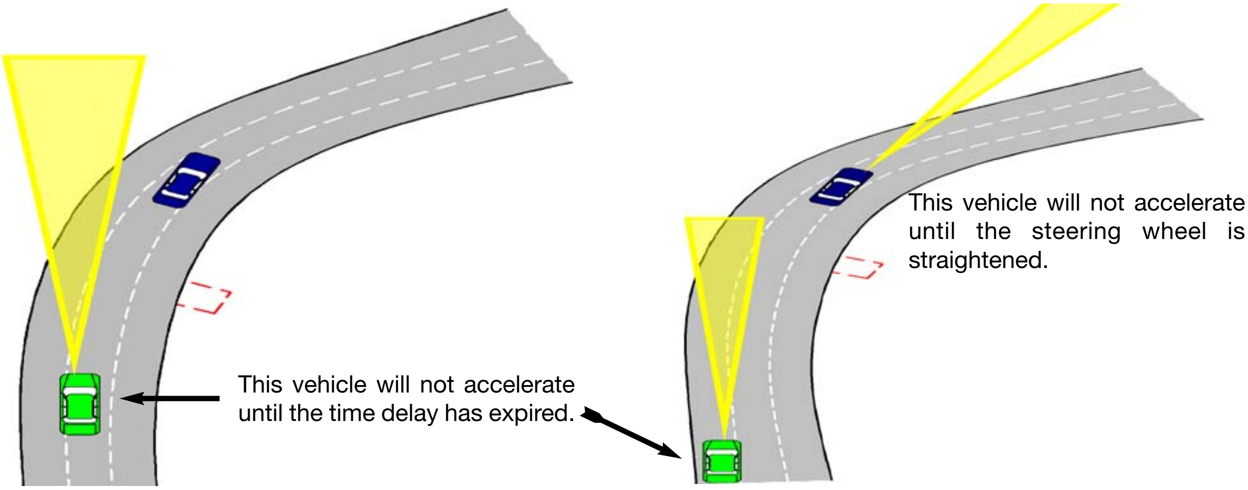
Updated Information

Deceleration

The ACC is only able to make limited relative speed corrections. The Maximum deceleration rate is 2.0 m/s2 **(20% of braking capacity)**. When the system has reached its function limits, the driver is requested to intervene by the flashing indicator.

Side Visual Range

Because of the limited side visual range, the leading object may be lost around curves. The ACC vehicle will not accelerate to the preset requested speed as long as the steering wheel is turned and curve recognition is active. After exiting the curve a time delay is in effect to prevent rapid overtaking of the lead object.



Lane Prediction

In order to select the correct lead object for vehicle to vehicle ranging, the ACC must predict the future lane or path of the vehicle (ACC vehicle).
Lead objects are then relevant to a control operation when they are located in the actual lane. Lane prediction is an advance calculation of the actual lane of travel.
The DSC unit provides vehicle speed and the Yaw sensor driving dynamics for the advance calculation.

Limitations

The following limitations are in effect during ACC operation:

- Operation possible only between the speeds of 20 mph and 110 mph.
- Maximum deceleration rate 2.0 m/s^2.
- Maximum acceleration rate 1.2 m/s^2.
- Maximum transversal acceleration rate 3.0 m/s^2.

ACC reaches its limitations in the following situations:

- The sensing range of the radar sensor limits the detection of objects that are traveling in front in different lanes or around curves.
- An object cutting in results in delayed ACC responses. Do not use ACC on winding roads or if frequent lane changes occur.
- High speed differences cannot be corrected.
- ACC cannot brake the vehicle to a complete standstill. The driver must assume control of the vehicle by braking.
- ACC must only be used when visibility is adequate.
- If the time gap to the lead object is less than 1 second, especially in the case of the lead object cutting in close to the front of the vehicle, ACC may not sense the lead object in time for intervention, driver intervention is required.

Activation Conditions

The following preconditions must be met for ACC to become operational:

- Engine speed > 512 RPM
- No failure of Irreversible faults present in ACC
- ACC system “ON”
- Driving Speed > 20 MPH
- Park, Reverse or Neutral not engaged
- Parking brake not engaged
- DSC not active

Operating Modes

Initialization Mode	All the ACC system components are checked after KL15 is active. The Radar sensor is checked from 20 km/h.
Passive Mode	Activation conditions are satisfied, ACC can be switched on by the Stalk Switch.
Standby Mode	ACC can be activated by the driver moving the stalk switch towards the instrument cluster '+' or towards the steering wheel '-' .
Active Control Mode	Normal ACC control mode in which the vehicle is controlled with automatic acceleration or deceleration.
Suspend Mode	ACC is not active, speed is controlled by the driver.
To-Standby Mode	Allows a smooth transition to Standby Mode when ACC is deactivated by the driver.
Brake only Mode	Only brake activation is possible, no DME intervention. This mode is active under the following conditions: -Fault in the DME -Radar Sensor "Blindness" -DSC intervention active -Parking Brake Activated Mode is terminated by accelerator pedal movement, or ACC deactivation.
Failure Mode	If a malfunction is detected ACC automatically switches directly into failure mode and the system is non-functional.

Deactivation

The ACC is deactivated in several ways:

- Raising or lowering of the Stalk Switch
- Pressing the brake pedal
- Placing the transmission in Neutral
- Deactivating the DSC System
- Failure of one of the subsystems (Automatic Deactivation)
- Sensor Blindness (Automatic Deactivation)
- Vehicle speed drops below the minimum operating range (Automatic Deactivation)
- The DSC is active beyond a preset time threshold (Automatic Deactivation)

Lens Heater

The lens of the ACC sensor is heated to ensure better operation in winter and adverse conditions. The heating coil is integrated into the plastic lens body.

Lens heating is temperature dependent as measured by an internal temperature sensor in the ACC unit.
Despite the heater it is not possible to prevent sensor “Blindness” in all conditions.

Faults with the lens heating system are registered in the ACC unit fault memory.

Fault Memory

Each module in the ACC system network stores its own faults. Faults that affect ACC operation are passed on the ACC control unit for action, ie. deactivation of ACC.

The ACC control unit stores and acts upon two different types of faults:

- **Irreversible Fault**
  ACC itself has detected an irreversible fault or communication is no longer possible with the DME or DSC (via the PT CAN). ACC is inactive until the fault is repaired and cleared.

- **Reversible Fault**
  ACC has detected a reversible fault in itself or a partner control unit. If the fault goes away ACC is immediately available for activation. An entry is made in the fault memory.

Alignment

It is essential that the sensor be correctly aligned for proper system operation. Horizontal mis-alignment will result in erroneous reaction to objects in a neighboring lane or a delayed reaction to objects in the same lane.

ACC can compensate for minor horizontal misalignments up to 1^0, with slight function impairments. In the event of more serious deviations, ACC will shut down and not be available for operation.

The alignment procedure is only possible with the DISplus or the GT1 and the special tools for ACC adjustment (PN 81-10-0-021-292).

Note: The tool is used in conjunction with other BMW special tools. Refer to SIB B03 01 01. Always refer to the latest bulletins and repair instructions.

Review Questions

1. What does the radar sensor monitor?

2. What is the meaning of the following symbols when displayed in the Instrument Cluster?

3. The following distance time intervals are?

4. How does ACC determine if brake application is necessary for proper deacceleration?

5. List the situations in which the ACC may reach its limitations.